Project Introduction

Thermal analysis is increasingly used in the engineering of spacecrafts at every stage, including design, test, and ground-operation simulation. Currently used high-fidelity modeling and simulation tools at NASA are computationally prohibitive and not fully compatible with integrated analysis of spacecrafts. We propose to develop and demonstrate an innovative Model Order Reduction (MOR) software to automatically generate nonlinear reduced thermal models for spacecraft analysis. The underlying principle of our approach is to project the original full models onto a characteristic, low-dimensional subspace, yielding reduced models with markedly low computational orders. During Phase 1, key technology elements were developed and proof-of-concept was successfully demonstrated. A MOR engine encapsulating carefully selected nonlinear MOR algorithms, a reduced model solver and a verification module along with facile data exchange interfaces, were developed in an integrated software environment. By way of whole-satellite (LISA) case studies, critical evidence was established that reduced thermal models enable unprecedented speedup (10⇔500X) and accuracy (<0.3%) for spacecraft analysis and design. In Phase 2, MOR engines will be optimized for enhanced computational performance. Robust constituent linear algorithms and domain-wise projection spaces will be developed to improve simulation stability and accuracy. New MOR capabilities to address variable-dependent models and parameterized MOR to accommodate design perturbations will be investigated. Our MOR software will be extensively verified and demonstrated for complex spacecraft thermal analysis. An application programming interface (API) will be developed in close collaboration with leading NASA vendors (C&R Technologies) to facilitate technology insertion and transition.

Software for Automated Generation of Reduced Thermal Models for Spacecraft Thermal Control, Phase II
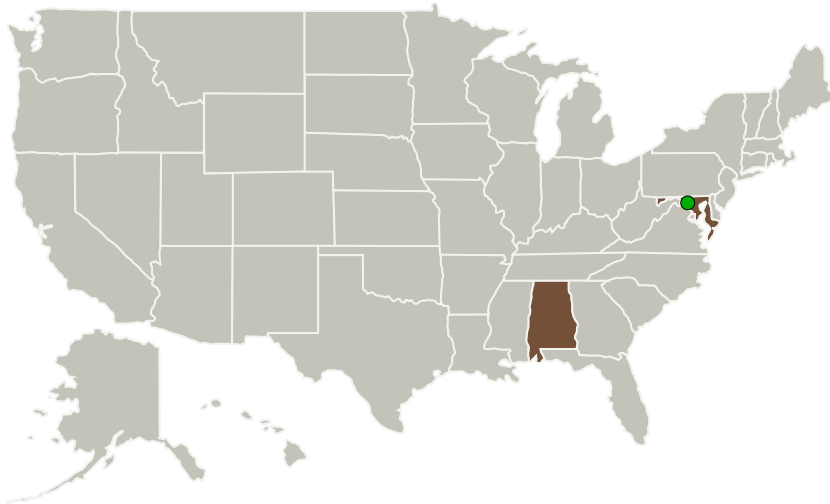
Table of Contents

Primary U.S. Work Locations and Key Partners

Organizations Performing Work	Role	Type	Location
CFD Research Corporation	Lead Organization	Industry	Huntsville, Alabama
🟢 Goddard Space Flight Center(GSFC)	Supporting Organization	NASA Center	Greenbelt, Maryland

Primary U.S. Work Locations	
Alabama	Maryland

Project Transitions

▶ **June 2011:** Project Start

✓ **February 2014:** Closed out

    Closeout Documentation:
- Final Summary Chart(*https://techport.nasa.gov/file/139349*)

Organizational Responsibility

Responsible Mission Directorate:

Space Technology Mission Directorate (STMD)

Lead Organization:

CFD Research Corporation

Responsible Program:

Small Business Innovation Research/Small Business Tech Transfer

Project Management

Program Director:

Jason L Kessler

Program Manager:

Carlos Torrez

Principal Investigator:

Yi Wang

Co-Investigator:

Yi Wang

Technology Maturity (TRL)

Start: **3**
Current: **5**
Estimated End: **5**

1	2	3	4	5	6	7	8	9
Applied Research			Development			Demo & Test		

Technology Areas

Primary:

- TX14 Thermal Management Systems
  └ TX14.2 Thermal Control Components and Systems
    └ TX14.2.5 Thermal Control Analysis

Target Destinations

The Sun, Earth, The Moon, Mars, Others Inside the Solar System, Outside the Solar System